Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 11(5): 1773, 20 October 2015 doi: http://dx.doi.org/10.15560/11.5.1773
ISSN 1809-127X © 2015 Check List and Authors

Range extension and molecular taxonomy of *Propeamussium arabicum* (Mollusca: Bivalvia: Propeamussiidae) from Indian waters

Anitha Rajan Arathi, Raveendhiran Ravinesh, Kottila Veettil Dhaneesh and **Appukuttannair Bijukumar***

Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram -695581, Kerala, India
* Corresponding author. E-mail: abiju@rediffmail.com

Abstract: The thin shelled pectinoidean bivalve, *Propeamussium arabicum* is a molluscan species originally described from Gulf of Aden. This paper records the first report of this species in Indian coast and explains the extended distribution of the species towards eastern Arabian Sea.

Key words: Arabian Sea; bivalve; distribution; Kerala; Pectinoida

The family Propeamussiidae (Abbott 1954) consists of small to medium sized, fragile and successful deep sea bivalves, often referred to as mud pectens (Sundberg 1989) due to their preference for soft muddy bottom, and also as glass scallops (Schneider et al. 2013) because of their transparent shells. According to Del Rio et al. (2008), propeamussiids were present in the shallow neritic environments until the early Cenozoic and gradually retreated to bathyal and abyssal regions. This family of mainly carnivores is distributed at depth ranging from the intertidal zone to 5000 m (Waller 2006) and has a cosmopolitan distribution, most of the species being reported from the Indo-Pacific region (Huber 2010). Propeamussiidae is characterised by thin, circular to subcircular translucent shells with a smooth prodissoconch (Dijkstra and Maestrati 2012), commarginally sculptured right valve made of inner layer of aragonite, middle layer of foliated calcite, and outer layer of columnar prismatic calcite, whereas the left valve is composed of inner layer of aragonite and outer layer of foliated calcite (Huber 2010). The members of this family are monomyarian, sinupalliate, lacking hinge teeth and ctenolium with simplified pseudolamellibranch gills, simple labial palps and type II stomach (Huber 2010).

This family includes about 150 species in five genera, represented by *Catillopecten*, *Cyclopecten*, *Propeamussium*, *Parvamusium* and *Similipecten* (Bouchet 2014). *Propeamussium* and *Parvamussium* have characteristic well-formed, widely spaced, distally disappearing internal calcitic ribs, while the former differs from the latter by the presence of internal ribs in early growth stages, the gape at the anterior and posterior margins and absence of byssal notch in the right valve (Dijkstra and Gofas 2004). Furthermore, *Parvamussium* has more prominent external sculpture than *Propeamussium*, with moderately deep byssal notch (Huber 2010) and the internal ribs appear late in the ontogeny (Dijkstra 1995). The genus *Propeamussium* consists of 24 species (Bouchet et al. 2014) of which five have been reported from India: *P. alcocki* (Smith, 1894), *P. andamanense* (Bavay, 1905), *P. andamanicum* (Smith, 1894), *P. caducum* (Smith, 1885) and *P. investigatoris* (Smith, 1906). In this paper we report on the first observation of *Propeamussium arabicum* (Dijkstra & Janssen, 2013) from the eastern Arabian Sea and provide sequence data of its mitochondrial gene cytochrome c oxidase 1 (CO1) and nuclear gene 18S rNA.

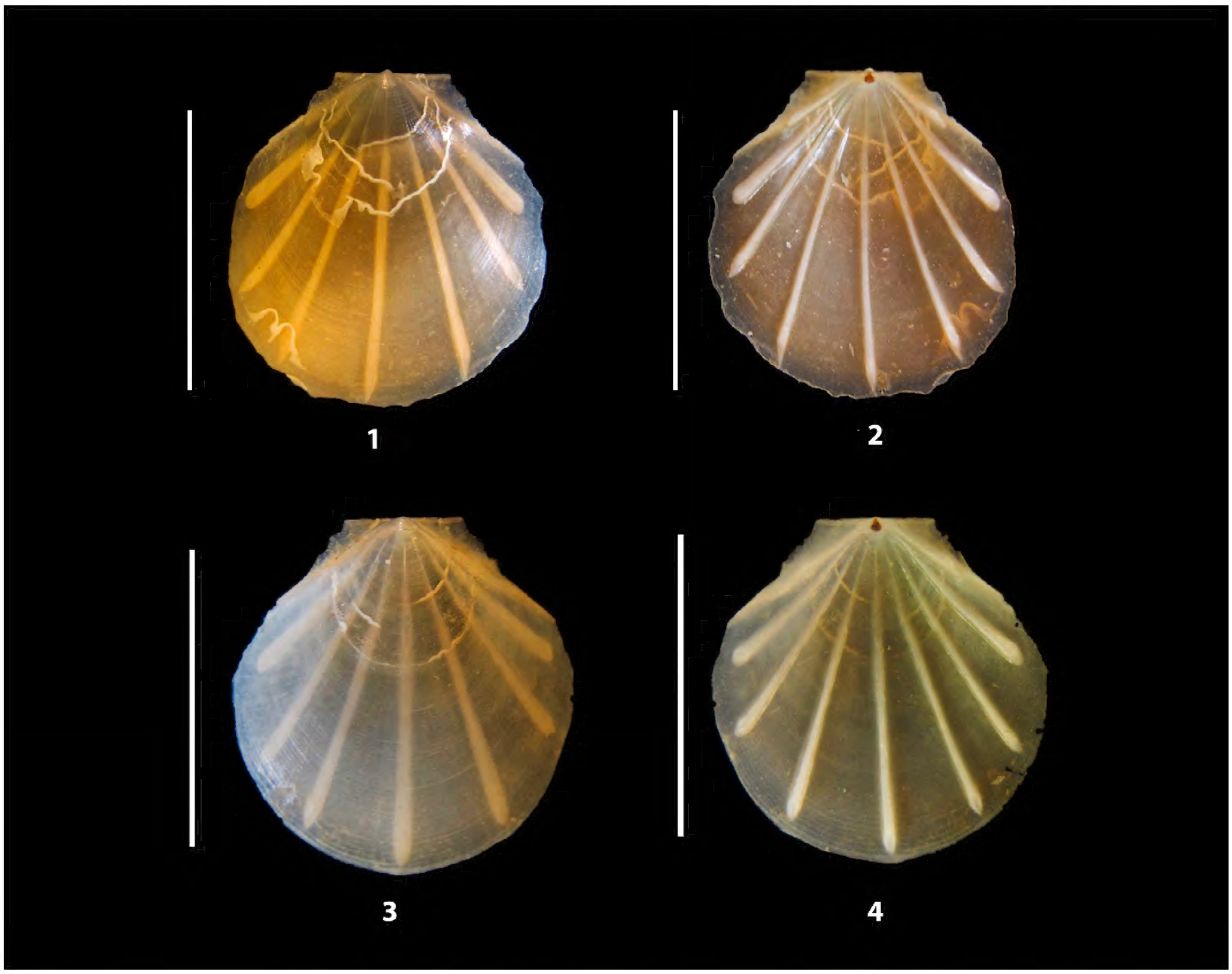
Thirty specimens were obtained from the commercial trawlers operating off Neendakara (latitude 08°56′ N to 09°20′ N and longitude 075°35′ E to 076°32′ E), Kerala coast, India, at a depth of about 200 m. Specimens were identified based on key characters and other morphological features (Dijkstra and Janssen 2013). Morphometric measurements such as height (along dorso-ventral axis) and length (antero- posterior) (Leal 2002) were recorded to the nearest millimetre using digital Vernier Calliper (Aerospace, China). Ten voucher specimens were deposited in the museum collections of the Department of Aquatic Biology and Fisheries, University of Kerala (DABF-UOK/BIV 1-10). The rest of the specimens were preserved in 95% ethanol for the purpose of molecular analysis.

Genomic DNA was extracted from the ethanol preserved muscle tissue of *P. arabicum* using DNeasy

Blood and Tissue Kit (QIAGEN, Hilden, Germany). The mitochondrial gene cytochrome c oxidase 1 (CO1) and nuclear gene 18S r RNA were amplified using the universal primers (Folmer et al 1994; Goto et al 2012) in a 25 µl reaction volume with *Taq* PCR master mix (QIAGEN, Hilden, Germany) and template DNA using the thermal cycler (Eppendorf, Hamburg, Germany). The PCR products were purified with ExoSAP- IT (USB) (Affymetrix Inc., Santa Clara, USA) and sequenced bidirectionally using the corresponding PCR primers and Big Dye Terminator V.3.1 Cycle sequencing Kit (Applied Biosystems Inc., Foster City, USA) in an ABI 3730 capillary sequencer (Applied Biosystems Inc., Foster City, USA).The raw DNA sequences were edited and aligned using BioEdit sequence alignment editor V.7.0.9.0. (lbisBiosciences, Carlsbad, USA., Hall 1999). Sequence divergences of both genes were estimated using the Kimura 2-Parameter distance model of MEGA (Version 6.0) Package (www.megasoftware.net/, Tamura et al. 2013). A maximum likelihood tree was constructed and bootstrapped with 1000 replications to provide percentage bootstrap values for branch points. Partial sequences generated in the present study were submitted in sequin format and are available in GenBank (KP691176 and KP406531).

Propeamussium arabicum Dijkstra & Janssen, 2013
Archiv für Molluskenkunde 142: 181– 214, 2013.
Figures 1–4

Small-sized, equilateral, inaequivalve higher than long transparent shells. Smooth and slightly unequal auricles without a byssal notch and ctenolium. Straight hinge line with triangular resilium lacking hinge teeth. Left valve more convex with central and periphery smooth, above central part of disc is many faint regularly spaced, antimarginal lirae crossed by unevenly arranged minutely undulated growth lines present 1 mm below the umbo. Right valve with close set commarginal lirae more prominent than in left valve. Prominent interior ribs on both valves (7 internal and 2 auricular ones). Interstitial riblets absent. Left valve colourful with an orange yellow tinge and irregular wavy commarginal white bands; right valve white.



Figures 1–4. *Propeamussium arabicum* Dijkstra& Janssen, 2013. Scale bar = 1 cm. **1**: Left valve (lv) exterior. **2**: Left valve (lv) interior. **3**: Right valve (rv) exterior. **4**: Right valve (rv) interior.

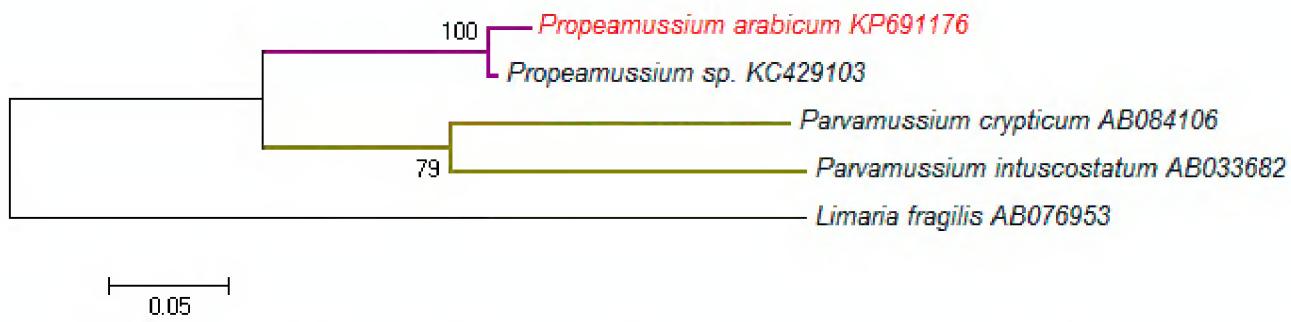


Figure 5. Maximum Likelihood (ML) tree of cytochrome oxidase subunit 1 (CO1) sequences of *Propeamussium arabicum* along with *Propeamussium* sp. obtained from GenBank.

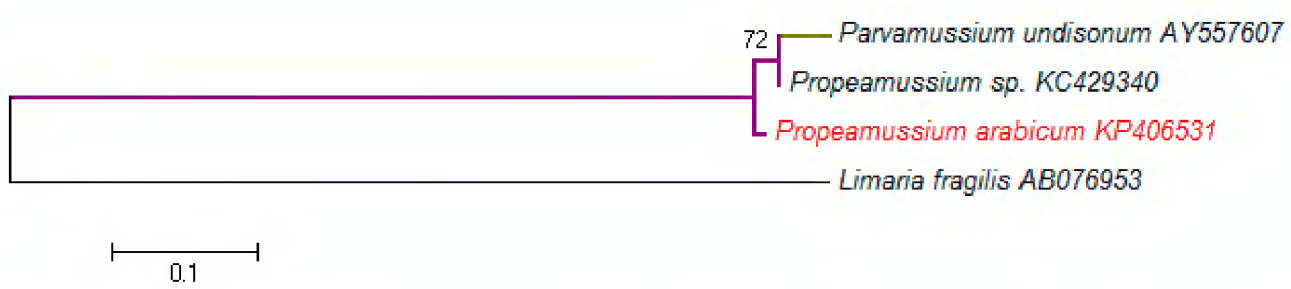


Figure 6. Maximum Likelihood (ML) tree of 18Sr RNA sequences of *Propeamussium arabicum* along with *Propeamussium* sp. obtained from GenBank.

DNA Barcoding (Figures 5 and 6): The 625 *Propeamussium arabicum* were sequenced. The nucleotide composition analysis revealed 40.32% GC content in CO1 sequence and 48.13% in 18S sequence. Blast search indicated 97% (mt CO1) and 98% (18S) similarity with the available sequences of *Propeamussium* sp. (KC429103 and KC429340). According to maximum likelihood analysis, the sequences of the species were well clustered with *Propeamussium* sp. available in GenBank with high boot strap value (Figures 5 and 6). Based on the sequence divergence, CO1 and 18S r RNA sequences of *P. arabicum* have lowest genetic distance of 0.021 and 0.023 from *Propeamussium* sp. (KC429103 and KC429340). DNA barcoding analysis was used for confirming the conventional taxonomy of our specimen which shows that the already present GenBank submissions (*Propeamussium* sp.) may possibly be that of *Propeamussium arabicum.*

Notes on distribution (Figure 7): The species *Propeamussium arabicum* was first recorded by Dijkstra and Janssen (2013) from the Gulf of Aden (12°21.5′ N, 044°33.0′ E) at a depth of 506 m. Since its first description, this species has not been recorded from elsewhere. The current record of this species from India extends its distribution approximately 2,000 km eastward in the Arabian Sea. Range extensions of species can be attributed to the composite effect of physical, biological and historical factors. Surface and subsurface currents which potentially connect habitats thousands of kilometres apart and the relatively constant limiting variables in deep sea such as light, oxygen, temperature and pressure over great distances are key factors for the dispersal of deep sea organisms (McClain and Hardy 2010). Moreover, the lecithotrophic development of the family Propeamussiidae (Huber 2010) may enhance their inherent ability for dispersal as species with planktonic larvae are expected to exhibit wider distribution patterns (Helmuth et al. 1994). Eastward distribution of about 30 species in superfamily Pectinoidea from tropical Indo-West Pacific region to Fiji and Tonga as reported by Dijkstra and Maestrati (2008) substantiates

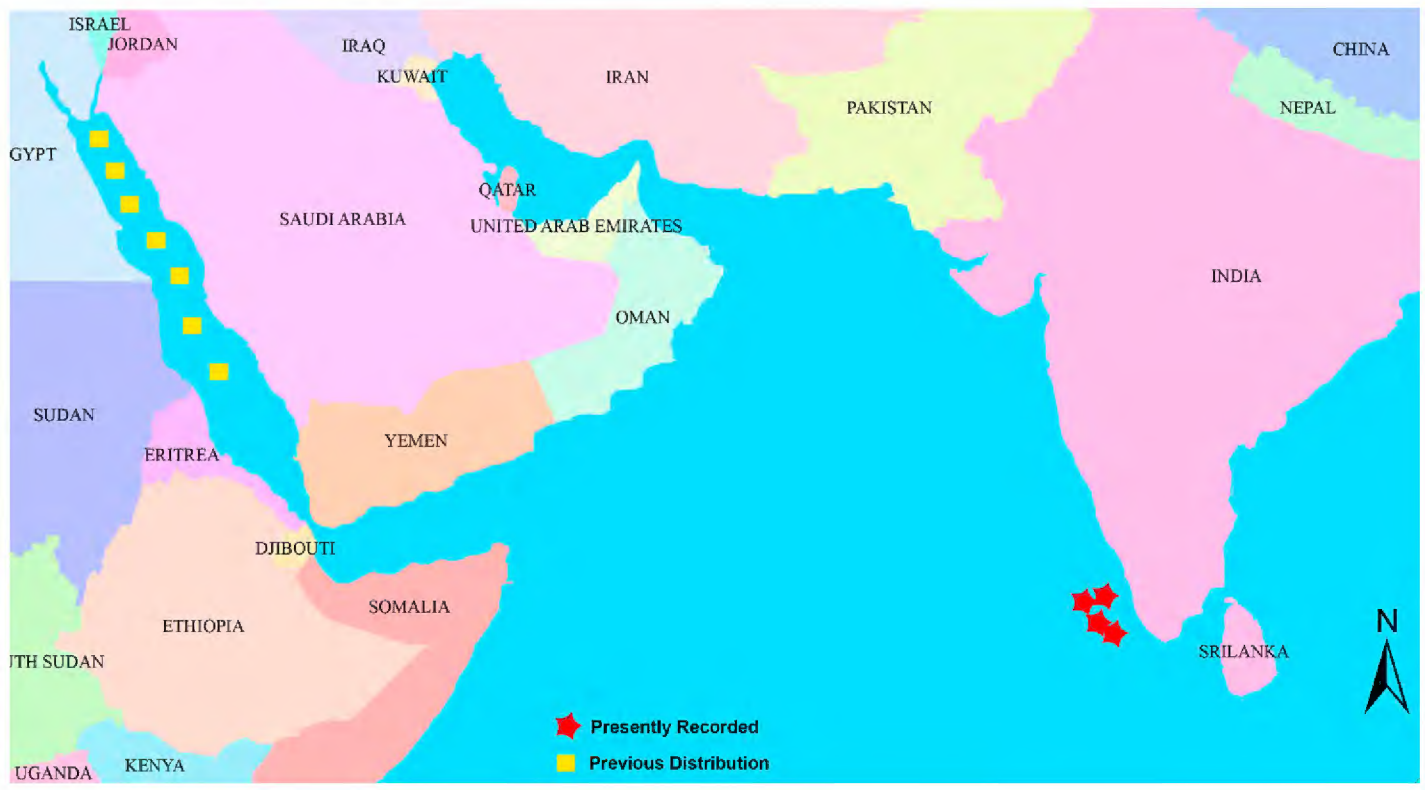


Figure 7. Distribution map of *Propeamussium arabicum;* red stars indicate current distribution along west coast of India and yellow squares represent early records in the Gulf of Aden.

the extended distribution exhibited by deep sea bivalves. More surveys and studies have to be carried out in order to understand and to document these organisms from Indian waters.

Material examined

The measured height (dorsal–ventral) and length (anterior–posterior) in mm of the voucher specimens are:

DABF-UOK/BIV 1 [height: 9.71(lv) 10.93(rv); length: 9.70 (lv) 9.86(rv)]; DABF-UOK/BIV 2 [height:10.79 (lv) 9.46(rv); length: 9.65 (lv) 9.01(rv)]; DABF-UOK/BIV 3 [height: 10.33(lv) 9.62(rv); length: 9.44(lv) 8.73(rv)]; DABF-UOK/BIV 4 [height: 9.17(lv) 8.52(rv); length: 8.36(lv) 8.16(rv)]; DABF-UOK/BIV 5 [height: 10.53(lv) 8.93(rv); length: 9.60(lv) 8.09(rv)]; DABF-UOK/BIV 6 [height: 10.45(lv) 9.84(rv); length: 9.04(lv) 9.05(rv)]; DABF-UOK/BIV 7 [height: 10.44(lv) 9.28(rv); length: 9.61(lv) 8.58(rv)]; DABF-UOK/BIV 8 [height: 10.14(lv) 9.64(rv); length: 9.64(lv) 8.98(rv)]; DABF-UOK/BIV 9 [height: 11.20(lv) 9.15(rv);length : 10.21(lv) 8.11(rv)]; DABF-UOK/BIV 10 [height: 10.07(lv) 9.05(rv); length: 9.55(lv) 8.53(rv)]

ACKNOWLEDGEMENTS

The authors thank the Department of Biotechnology, Government of India for the financial support of the project. ARA thanks Kerala State Council for Science Technology and Environment for the fellowship offered for studying the taxonomy of bivalve molluscs. Thanks are due to Graham Oliver, National Museum Wales, Cardiff, United Kingdom and Henk. H. Dijkstra, Naturalis Biodiversity Centre, Leiden for confirming the taxonomic identification.

LITERATURE CITED

Bouchet, P. [2014]. Propeamussiidae Abbott, 1954. Accessed at http://www.marinespecies.org/aphia.php?p=taxdetails&id=156983, 4 September 2014.

Bouchet, P., H. Dijkstra and S. Gofas. [2014]. *Propeamussium*. Accessed at: http://www.marinespecies.org/aphia.php?p=taxdetails&id=138324, 4 September 2014.

Del Rio, C.J., A.G. Beu and S.A. Martinez. 2008. The pectinoidean genera *Delectopecten* Stewart, 1930 and *Parvamussium* Sacco, 1897 in the Danian of northern Patagonia, Argentina. Neues Jahrbuch für Geologie und Paläontologie 249: 281–298. doi: 10.1127/0077-7749/2008/0249-0281

Dijkstra, H.H. 1995. Bathyal Pectinoidea (Bivalvia: Propeamussiidae, Entoliidae, Pectinidae) from New Caledonia and adjacent areas. Memoires du Museum d'Histoire Naturelle 167: 9–73. doi: 10.5252/z2013n3a2

Dijkstra, H.H and S. Gofas. 2004. Pectinoidea (Bivalvia: Propeamussiidae and Pectinidae) from some northeastern Atlantic seamounts. Sarsia 89: 33-78. doi: 10.1080/00364820410003469

Dijkstra, H.H. and P. Maestrati. 2008. New species and new records of deep water Pectinoidea (Bivalvia, Propeamussiidae, Entoliidae and Pectinidae) from the South Pacific; pp. 77–113, in: V. Heros, R.H. Cowie and P. Bouchet (eds.). Tropical deep sea benthos 25. Memoires du Museum National d'Histoire Naturelle 96.

Dijkstra, H.H. and P. Maestrati. 2012. Pectinoidea (Mollusca, Bivalvia, Propeamussiidae, Cyclochlamydidae n. family, Entoliidae and Pectinidae) from the Vanuatu archipelago. Zoosystema 34: 389–408. doi: 10.5252/z2012n2a12

Dijkstra, H.H. and R. Janssen. 2013. Bathyal and abyssal Pectinoidea from the Red Sea and Gulf of Aden. Archiv für Molluskenkunde 142: 184-214. doi: 10.1127/arch.moll/1869-0963/142/181-214

Folmer, O., M. Black, W. Hoeh, R. Lutz and R. Vrijenhoek. 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299.

Goto, R., A. Kawakita, H. Ishikawa, Y. Hamamura and M. Kato. 2012 . Molecular phylogeny of the bivalve superfamily Galeommatoidea (Heterodonta, Veneroida) reveals dynamic evolution of symbiotic lifestyle and interphylum host switching. BMC Evolutionary Biology 12: 172. doi: 10.1186/1471-2148-12-172

Helmuth, B., R.R.Veit, and R. Holberton. 1994. Long distance dispersal of a subantarctic brooding bivalve *Gaimardia trapesina* by kelp rafting. Marine biology 120: 421-426. doi: 10.1007/BF00680216

Huber, M. 2010. Compendium of bivalves. Hackenheim, Germany: Conchbooks. 795 pp.

Leal, J.H. 2002. Bivalves; pp. 26-98, in: K.E. Carpenter (ed.). FAO Species Identification Guide for Fishery Purposes, The living marine resources of the Western Central Pacific — introduction, molluscs, crustaceans, hagfishes, sharks, batoid fishes and chimaeras. Rome: FAO.

McClain, C.R. and S.M. Hardy. 2010. The dynamics of biogeographic ranges in the deep sea. Proceedings of the Royal Society Britain 277: 3533-3546. doi: 10.1098/rspb.2010.1057

Schneider, S. J.S. Crampton and A. Lukeneder. 2013. Propeamussiidae, Inoceramidae, and other Bivalvia from the Lower Cretaceous Puez formation (Valanginian–Cenomanian; Dolomites, South Tyrol, Italy). Cretaceous Research 46: 216–231. doi: 10.1016/j.cretres.2013.09.002

Sundberg, F.A. 1989. Propeamussium species (Bivalvia: Propeamussiidae) from the Upper Cretaceous of Southern California. Journal of Paleontology 63: 53–63. http://www.jstor.org/stable/1305481

Tamura, K., G. Stecher, D. Peterson and S. Kumar. 2013. MEGA6: Molecular Evolutionary Genetics Analysis Version 6.0. Molecular Biology and Evolution 30: 2725–2729. doi: 10.1093/molbev/mst197

Waller, T.R. 2006. Phylogeny of families in the Pectinoidea (Mollusca: Bivalvia): importance of the fossil record. Zoological Journal of the Linnean Society 148: 313–342. doi: 1096-3642.2006.00258.x

Authors' contribution statement: ARA and RR carried out the field work in the southwest coast of India and were involved in the preparation of the paper. KVD performed the molecular taxonomy. ABK was involved in taxonomic identification and preparation.

Received: 9 August 2015
Accepted: 3 November 2015
Academic editor: Robert G. Forsyth